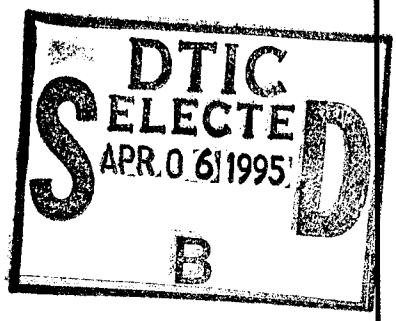
AOARD REPORT

Virtual Reality Software and Technology '94



22-26 August, 1994

T. Davis
AOARD

A summary of the Virtual Reality Software and Technology '94 conference, conducted August 22-26, 1994 at the National Institute of Science and Technology of Singapore is presented. Abstracts of all presented papers are included, as is a complete list of conference registrants. This report is based upon information collected via conference attendance, review of the proceedings, and conversations with other attendees.

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1. Event Organization and Background.

Virtual Reality Software and Technology '94 (VRST '94), which is intended as the first in a series of annual VR conferences, was conducted at the Institute of Systems Science (ISS) of the National University of Singapore on 23-26 August, 1994. VRST '94 was co-sponsored by ISS and the Association for Computing Machinery's Special Interest Group for Computer-Human Interaction (ACM/SIGCHI). The General Chair for the conference was Dr. Juzar Motiwalla, Director ISS. His contact information, along with that of Dr. Steve Feiner from Columbia University, who served as co-chair of the Program Committee, appears below.

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The VRST '94 technical program is summarized in Section 2 below. As noted there, the first day of the event (Tuesday morning, 23 August) was devoted to a collection of parallel tutorial sessions. The primary conference technical program began the following morning (Wednesday, 24 August) with the program co-chair opening remarks, guest speech and keynote address. The remainder of the conference technical program consisted of paper, demonstration/video and panel sessions. Abstracts of all presented papers are included in Section 4.

A complete list of conference registrants, including affiliation, is included in Section 3 below. Review of the list indicates that VRST '94 attracted a large and diverse group of international participants. About 120 people, representing 15 different nationalities, attended the event.

As noted above, VRST '94 is intended as the first in a series of annual virtual reality workshops. During the opening session, Tokyo and Switzerland were announced as the venues for VRST '95 and VRST '96 respectively, however no specific dates were established for either event.

2. Technical Program Synopsis.

The VRST '94 technical program included a full day (Tuesday, 23 August) devoted to virtual reality tutorial sessions. The tutorials were conducted in

parallel with one full day and four one half day programs. The titles, instructors and durations of the tutorial sessions are listed below. Tutorial number 2, titled Three Dimensional Graphics Hardware, was cancelled at the conference site, but all others were conducted as scheduled.

Tutorial 1 (Full Day): Introduction to Virtual Reality Design
Steve Bryson, NASA Ames, USA
Steven Feiner, Columbia University, USA

Tutorial 2 (Half Day): Three Dimensional Graphics Hardware (Cancelled)
Tai-cker Chiueh, State University of New York, Stony Brook, USA

Tutorial 3 (Half Day): dVise - Using the Virtual Design Environment(tm) with your Existing CAD Models
Pierre duPont, Division Limited, UK

Tutorial 4 (Half Day): Geometrical Modeling and Animation for VR
Mark Green, University of Alberta, Canada

Tutorial 5 (Half Day): Graphical and Acoustical Rendering for VR
Peter Astheimer and Stephan Muller, Fraunhofer-Institute for Computer Graphics, Germany

The full day tutorial, titled Introduction to Virtual Reality Design and conducted by Bryson and Feiner, was a very comprehensive survey of the field. It included sessions on interface technology, human factors, performance issues, architectures and case studies. The emphasis throught was on state of the art developments. The course handout material consists of some 84 pages of viewgraph hardcopy (two per page).

The main conference program began on Wednesday morning, 24 August with an opening speech by Radm. Teo Chee Hean, Singapore Minister of State for Finance and Communications. Adm. Hean addressed the conference in the context of virtual reality as a component of Singapore's Information Technology national research and development objectives. He indicated that Singapore considers information technology to be a key to its long term competitiveness and intends to vigorously pursue international linkage opportunities such as VRST '94 in the future.

The next event on the conference agenda was the keynote address (an abstract appears in Section 4), delivered by Michael Deering from Sun Microsystems. A central theme of his address was a concern that the VR research communuity might allow expectations to exceed what can be delivered. He noted that about a decade ago the Artifical Intelligence community allowed something of the sort to happen to its discipline, with adverse consequences. Other key points in his address were that (1) successful commercialization of VR will require somethingh on the order of a $10K system which provides about X1.5 productivity improvement at about 2hrs/day utilization and allows a 2 year capital recovery period, and (2) that the VR research community needs to quickly answer the question "What is the killer application?"

The remainder of the conference technical program was divided into a series of paper, panel and demonstration/video sessions. Abstracts of all presented papers, demonstrations/videos and panel session opening remarks are

provided in Section 4. They are collected by session title and appear in the order presented.

3. Conference Registrants.

Following is a complete list of VRST '94 conference registrants, including country and organizational affiliation.

Country	*Name*	Organization
Korea	AHN Seung Kwon	GoldStar Central Research
Austria	AIGNER Wolfgang	Technische Universitat Graz
Singapore	ANG Chuan Heng	National University of Singapore
USA	APPLEWHITE Hugh	Piltdown Inc
Germany	ASTHEIMER Peter	Fraunhofer-Institute for Computer Graphics
Spain	BAYARRI Salvador	ARTEC
UK	BENJAMIN Ivor	City Univ
USA	BRYSON, Steve	NASA Ames
Singapore	CHAI Theong Ham	Ngee Ann Polytechnic
Singapore	CHAN Hwee Bin	Defence Science Organisation
Singapore	CHAN Wai Fun	Reuters
Singapore	CHANG Ivan	Ministry of Defence
Singapore	CHIN Wei Ngan	National University of Singapore
Singapore	CHIN Yee Lin	Temasek Polytechnic
Singapore	CHUA Beng Choon	ISS, National University of Singapore
Singapore	CLAMTON Debbie	Singapore Polytechnic
UK	COOPER Maggie	City University
Japan	DAVIS Thomas	USAF AFOSR/AOARD
USA	DEERING Michael	Sun Microsystems
Thailand	DENISON Michael A	Riche Monde
Singapore	DUSAD Vishnu	Nucleus Software Solutions
Singapore	EICKEMEYER John Scott	National Computer Board
Sweden	FAHLEN Lennart Erik	Swedish institute of Computer Science
Singapore	FAIRCHILD Kim	ISS, National University of Singapore
USA	FEINER Steven	Columbia University
USA	FOXLIN Eric	MIT
Canada	GREEN Mark W	Alberta University
Singapore	HAN Yeow Kwang Harry	Defence Science Organisation
Singapore	HENG Pheng Ann	ISS, National University of Singapore
Singapore	HII Toh Onn Desrnond	ISS, National University of Singapore
Japan	HIROSE Michitaka	University of Tokyo
Sweden	JAA-ARO Kai Mikael	Interaction & Presentation Laboratory
Germany	JACOBS Joerg	Art & Com
Singapore	JARZABEK Stan	National University of Singapore
Japan	JUN Rekimoto	Sony Computer Science Laboratory Inc
Japan	KAHANER David K	US National Institute of Standards and Technology
Singapore	KAN Chi Ming	Temasek Polytechnic
Singapore	KAWATAKE Tsutomu	JSAIC
Country	*Name*	Organization
Singapore	KELLOCK Peter	ISS, National University of Singapore
Japan	KOMORI Shinya	University of Tokyo
Japan	KUBOTA Makoto	Japan Research Institute Ltd
Singapore	KWEE Tiaw Joo	Ngee Ann Polytechnic
Singapore	LAU William	Defence Science Organisation
Singapore	LEE Beng Hai	ISS, National University of Singapore
Singapore	LEE Mong Li	National University of Singapore
Singapore	LEE Yiew Leng	ITS Technologies Pte Ltd
Singapore	LEONG Hon Wai	National University of Singapore
Singapore	LEONG Josephine	Japan-Singapore Institute of Software Technology
Singapore	LIEW Hui Ming	ISS, National University of Singapore
Singapore	LIM David	Ngee Ann Polytechnic
Singapore	LIM Ik Soo	ISS, National University of Singapore

Singapore	LIM Song Lian Albert	Nanyang Polytechnic
Singapore	LING Si Eng	Ngee Ann Polytechnic
USA	LIU Andrew	Nissan Cambridge Basic Research
Singapore	LOKE Kong Lang, Michael	Ngee Ann Polytechnic
Japan	MEYER Richard E	USA STCFE
Singapore	MIKHAILOV Alexei	Ngee Ann Polytechnic
India	MITRA Sugata	NIIT Ltd
Singapore	MOTIWALLA Juzar	ISS, National University of Singapore
Germany	MULLER Stefan	Fraunhofer-Institute for Computer Graphics
Singapore	NG Hern	ISS, National University of Singapore
Singapore	NG Teow Khoon	National Computer Board
Singapore	NGUYEN H T	ISS, National University of Singapore
Japan	NOMURA Junji	Matsushita Electric Works
Singapore	NOWINSKI Weslaw	ISS, National University of Singapore
Japan	OGI Tetsuro	Mitsubishi Research Institute
Singapore	ONG Hian Leong	Systems & Computer Organisation
Singapore	ONG Lennox	Alliance Multimedia Corporation Pte Ltd
Singapore	ONG Siong Huat	Defence Science Organisafion
Singapore	PNG Willie	ISS, National University of Singapore
Singapore	PO0 Danny Chiang Choon	National University of Singapore
Singapore	POSTON Timothy	ISS, National University of Singapore
Singapore	QUEK Chee Siong	Japan-Singapore Institute of Software Technology
USA	QUEK Francis	University of Illinois at Chicago
Singapore	QUEK Yew Leng Steven	DISC, National University of Singapore
India	RAWLA Anuj	V R Real Technologies (Pte) Ltd
Singapore	SAKAMOTO Yoshihiro	JSAIC
Singapore	SERRA Luis	ISS, National University of Singapore
Japan	SHIMI7U Atsushi	Japan Research Institute Umited
Singapore	SHOJI Hayato	JSAIC
Singapore	SIEW Teng Kean	National University of Singapore
Singapore	SINGH Gurminder	ISS, National University of Singapore
UK	SLATER Mel	Queen Mary & Wesffield Univ of London
UK	SNOWDON David	University of Nottingham
Singapore	SOH Chee Yuen	ITS Technologies
Korea	SONG Kyung Joon	Electronics & Telecommunications Research Institute
Germany	SPERLICH Tom	Press
Canada	STAMPE Dave	University of Toronto
Netherlandslands	STAPPERS Pieter Jan	Delft University of Technology
UK	STEED Anthony	Queen Mary & Westfield University of London
USA	SU S Augustine	Texas A&M University
Singapore	SUNG Kelvin	National University of Singapore
Singapore	SYN Peck Khay	Defence Science Oorganisation
Singapore	TAI Chiew Lan	National University of Singapore
Singapore	TAN Chris	Ministry of Defence
Singapore	TAN Gary	National University of Singapore
Singapore	TAN Lam Wing	Ngee Ann Polytechnic
Country	*Name*	Organization
Singapore	TAN May Lee	Ngee Ann Polytechnic
Japan	TANZO William	Saitama University
Singapore	TEH Hung Chuan	National University of Singapore
Singapore	TEO Ming Tat	Ngee Ann Polytechnic
Switzerland	THALMANN Daniel	Computer Graphics Laboratory
Singapore	TOH Eng Kheem	Ngee Ann Polytechnic
Germany	TRAMBEREND Henrik	Art & Com
UK	USOH Martin	Queen Mary & Westfield University of London
Belgium	VAN BINST Paul	University of Brussels
Singapore	VANNAKRAIROYN Surasit	Elcom: Antech Grp
Singapore	WEE Khoon Hoe Jarrod	ITS Technologies
USA	WEXELBLAT Alan	MIT Media Laboratory
Korea	WOHN Kwangyoen	KAIST

Singapore	WONG Yin Fun, Audrey	ISS, National University of Singapore
Singapore	WOON See Chin	ISS, National University of Singapore
Korea	YI Geun	KAIST
Singapore	YII Buoh Hing	Ngee Ann Polytechnic
UK	YIP David	Division Lid

4. Abstracts of Presented Papers.

Following is a complete set of abstracts for all papers, demonstrations/videos and panel session opening remarks presented at VRST '94. They are collected by session title and in the order presented at the conference.

Opening Session:

Keynote Address

FACING THE CHALLENGE:

DELIVERING VIRTUAL REALITY

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EXTENDED ABSTRACT

With more than half a decade of concept demonstrations behind it, it is time for Virtual Reality to start facing up to the challenge of delivering real systems. We have to be brave enough to state quantitatively what makes a system Virtual Reality, as opposed to advanced multimedia or just 3D graphics. The field has to find a way to be inclusive while still stating that frame rates and lags that were known to be unacceptable more than 200 years ago are still unacceptable today.

By definition, to grow beyond a niche market, technical appalications of Virtual Reality must be found with broad market appeal. To be fiscally viable, the gains such applications bring in end-user productivity must exceed any extra hardware costs.

There is room for optimism as well, however. Several recent technical advances within Sun's VR effort will be described. These include: nearly no-lag head tracking, HoloCam: a 32-channel stereo camera for live telepresence, some recent dramatic advances in low cost high speed rendering hardware, and HoloSketch: a completely VR based 3D sketching animation authoring system. HoloSketch is an example of a potential high volume application for technical Virtual Reality: a general purpose tool for non-programmers who need to easily create and manipulate 3D shapes and worlds.

Paper Session: Gestures

NATURAL GESTURE IN VIRTUAL ENVIRONMENTS

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I present an experiment and the resulting prototype on a new method for interacting with virtual environments. This method involves the capture and use of natural empty-hand gestures. Users are allowed to gesture in their normal continuous manner, rather than being restricted to a small set of discrete gestural commands. Gestures are captured and analyzed into a higher-level description. This description can be used by an applicationspecific interpreter to understand the gestural input in its proper context. An analyzer of this sort enables natural gesture input to any appropriate application.

Toward a Vision-Based Hand Gesture Interface

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May 11, 1994

ABSTRACT

We present a two-pronged approach to vision-based gesture recognition of an unencumbered hand. Our goal is a gesture interface that makes sense from the standpoint of human usage, and which can be implemented by machine vision. We first explore gesture interpretation and usage among humans. We glean rules and principles which permit us to define a representative gesture taxonomy and provide information on gesture segmentation and usage. This analysis indicates that the dynamics of hand gestures are of critical importance in their segmentation and interpretation. Second, we apply vector field computation to gesture interpretation.

We extract vectors in a three-stage process. First, we extract moving edges using a motion-enhancing edge detector. Second, we compute an initial vector field estimate. Finally, we smooth this vector field to produce a locally aligned field which minimizes noise. Results of our system indicate that the approach is suitable for such interpretation.

KEYWORDS: Human-Computer Interaction, Gesture input, Optical Flow, Dynamic Vision, Gesture Interpretation

A LOGICAL HAND DEVICE IN VIRTUAL ENVIRONMENTS [a]

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and

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ABSTRACT

The human hands are the major means through which we gain our primary connection to the world. The modeling of human hands is a very important issue in virtual environments, however little research has been done to support higher levels of abstraction of using hands beyond that of just capturing raw data.

In this paper we present an alternative view of hand modeling, i.e., a point-based hand model, and then investigate 3D static hand gestures in detail. Thereby, we develop a device-independent and general-purpose logical hand device, which supports the use of comprehensive 3D gestural input in virtual environments. Based on our logical hand device, not only can the implementation of "point, reach, and grab" interaction be facilitated, but also American-Sign-Language-like static gestures can be conceived easily.

KEYWORDS: virtual environments, hand models, 3D gestures, logical hand device, American Sign Language

Paper Session: Modeling & Animation

STEPS AND LADDERS IN VIRTUAL REALITY

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ABSTRACT This paper describes a technique for walking through, and climbing or descending steps and ladders in virtual reality. The idea is that human participants in the *virtual* reality (VR) carry out a whole body gesture similar to walking, by walking in place. A pattern analyser distinguishes between walking in place behaviour, and any other behaviour, and moves the participant through the environment when it detects the walking in place. Such "walking" while on steps or ladders similarly causes appropriate virtual movement. We discuss this in the context of a paradigm for interaction called "body centred interaction ". This attempts to maximise the match between the mental body model formed as a result of proprioceptive information generated by limb and body movements, and the sensory data displayed by the VR system, within the constraints imposed by limited tracking information. We argue that the sense of presence in the VR is enhanced by such body centred interaction techniques, and we present experimental evidence in support of this claim.

FUZZY AGGREGATION OF MOTION FACTORS FOR HUMAN MOTION GENERATION 1

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ABSTRACT

Human motion generation is one of the important issues in computer animation. To generate a realistic human motion, various information of

body joints are needed, and dynamics gives the solution to this. However, formalizing complex human motions and solving these equations are computationally expensive. To get an interactive and realistic human motion, we made use of dynamic property which allows to use several key human motion factors. In this paper, we select four key human motion factors and propose an aggregation method using fuzzy logic. We implemented an animation system based on this method, and numerous experimental results showed that the proposed method generates an interactive and realistic human motion. Such a human motion generation can be easily adapted in virtual reality systems that make use of human animation within virtual world.

A Geometric Modeling and Animation System for Virtual Reality

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Abstract

Very few virtual environment design tools have been developed for non-programmers. Most non-programmers rely on programmers to produce their environments, or produce static environments using traditional geometrical modelets. Non-programmers, including artists and designers, have a lot to contribute to the development of virtual environments. In addition, tools developed to assist this user group will also benefit other virtual environment developers.

A highly interactive 3D geometry modeling system and animation editor (JDCAD+) is presented in this paper. The motivation behind this project is to develop interactive tools for creating animated objects and importing them into virtual environments. Without such tools, creating animated objects requires coding the geometry and behavior of the object manually. Such models are usually very time consuming to code and lack detail. Coding behaviors for animation can also be very difficult due to complicated equations of motion that need to be solved. Using key frame animation has resulted in faster and easier behavior generation.

Demonstrations & Videos

UNIVERSITY OF ALBERTA 3D MODELING TOOLS

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ABSTRACT

Over the past few years a number of 3D geometrical modeling tools have been developed at the University of Alberta. The main thesis behind these tools *is* that 3D design can best be performed using a 3D user interface with 3D input devices. The geometrical modelers presented in this demonstration will illustrate this idea and convince you that it is reasonable. The first modeler, JDCAD, is a CSG modeler for the mechanical engineering and industrial design communities. The second modeler, JDCAD+, is an early version of JDCAD that includes interactive behavior specification. The third modeler, Thred, is an experimental two handed free form surface editor.

Interactive Visualization of a Beating Heart:

A Medical Application of the Virtual Workbench

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ABSTRACT

An interactive system for visualizing and manipulating beating heart data has been enhanced by using the Virtual Workbench interface. The new system allows intuitive visualization of time and space stacks of the dynamic cardiac MRI data and it also provides a 3D interface for manipulating such 4D data.

THE VIRTUAL ENVIRONMENT THEATER™ AS AN ARCHITECTURAL AND URBAN DESIGN REVIEW SYSTEM

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In June 1994, for the annual A/E/C SYSTEMS'94 conference - the building industry's "SIGGRAPH" - Worldesign designed and built a Virtual Environment Theater, or VET™, as a prototypical virtual worlds-based architectural and urban design review system. Over 3,000 professionals in the fields of architecture, engineering, and construction (about a tenth of the attendees) experienced in the VET several different potential versions of the Port of Seattle's "Central Waterfront Development Project", as if they were involved in an actual environmental impact review.

The idea behind the VET is to "virtualize", or make more immediately accessible, the vast amount of information contained in the Port of Seattle's dense environmental impact statement (EIS). In the United States, issuance of an EIS usually precedes any major construction or development. The EIS then becomes an object of debate between development proponents and opponents. The public, which is supposed to be the prime beneficiary from this process, is often excluded from the review since the information contained in the EIS is presented in arcane language and without graphics or sound.

The VET permits representatives of the public to better understand what is being proposed for a particular development and the implications for its surrounding natural and built environments. Information can be imbedded in visual and acoustic objects, so that buildings can "speak" their prospective history and effects when called upon. During our showing of the VET at A/E/C SYSTEMS, however, we discovered that the VET has a more essential use, to help align the visions of the various parties - not least, the clients - collaborating in the design, building, and use of a new development or construction. Often the failure to align visions causes the greatest disappointment (and expense) down the line, when the designers, builders, and clients suddenly discover they do not have the same vision of their common enterprise. In a shared virtual world, it is easier to actively involve everyone in the review and, when necessary, reformulation of basic plans, from the beginning. The value of this consensus-building property of the virtual environment cannot be overstated.

The physical part of the VET is a large, multiscreen, shared interactive virtual environment. Up to 20 persons can step into the 270-degree FOV space defined by three 4.25 x 3.25-meter rear-projection screens. Each screen is lit by intensely bright Hughes-JVC 310 light-valve video projectors. In turn, each of the three projectors is driven by a Digital AXP workstation paired with a Kubota Denali graphics subsystem; a fourth Digital workstation synchs up the network. The Worldspace©, the virtual world running within the VET, is constructed of models built in 3D Studio, a world framework provided by Sense8's WorldToolKit, and Worldesign's own proprietary Reality Works© software. For our installation, Visual Synthesis Inc. provided spatialized sound and Kintek Stereo the sound-surround apparatus.

Funding for the VET was provided by ARPA, the U.S. Defense Department research wing, and by Environmental Systems Research Institute Inc., the leading GIS (geographic information systems) vendor.
In the future, Worldesign will bring the VET home to Seattle for installation at the Port. After several months of upgrading the basic Worldspace - using newly available CAD models for the buildings, rather than the crude sketches in the current EIS - the VET will be ready to import analytical algorithms governing traffic congestion, economic return of different types of development, polltion and energy profiles of buildings, and so forth. Over time it will become a highly useful system for design review well-integrated with the way things are done today, but offering many new opportunities for innovation and experimentation. Ultimately, VETs will be networked to provide shared environments that transcend space and time.

Dancing with the Virtual Dervish: Virtual Bodies

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with
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ABSTRACT

Dancing with the Virtual Dervish: Virtual Bodies is a collaborative project in virtual reality (VR) by visual artist and designer Diane Gromala, choreographer Yacov Sharir, and composer Russell Pinkston. It was funded by a major grant from the Cultural Initiatives Program of the Department of Communications Canada through a two-year residency at the Banff Centre for the Arts in Canada. This project and the six others in the Art and Virtual Environments Project, selected from among an international pool of artists working in virtual reality, represented a remarkable opportunity. The Banff Centre provided each of the collaborative groups with a team of engineers, a highly technologically literate art assistant, and access to a high-end Silicon Graphics machine, head-mounted displays, data-gloves, trackers, and state-of-the-art television, film, and sound studios. Through intensive periods of research and testing, *Dancing with the Virtual Dervish: Virtual Bodies* resulted in a dance performance where the dancer and audience members perform and interact with a virtual environment in real-time. Large-scale video projections of what each interactor experienced created another level of VR in the performance space, and turther encouraged participation. The opportunities and limitations of the technology were embraced and pushed, resulting in new creative strategies and directions for further technological development.

Paper Session: Architectures

A USER-DEFINED VIRTUAL ENVIRONMENT DIALOGUE ARCHITECTURE

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ABSTRACT

This paper describes a manipulable dialogue architecture that allows the participant in a virtual environment to change how their gestures affect the virtual environment. The dialogue structure has a visual representation within the virtual environment that can be manipulated to alter the gestures that are recognised, or to create new gestures. An implementation is described and the benefits that this ability to change the interaction gestures from within the environment are discussed.

DESIGNING IN VIRTUAL REALITY: IMPLEMENTING PERCEPTION-ACTION COUPLING WITH AFFORDANCES

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ABSTRACT

In this paper we describe a package we are developing for computer aided design (CAD) in virtual reality (VR). We present both the version of tim design package that has been realized and the final mode of interaction that we are aiming for. We believe that designing in virtual reality has some advantages over designing with an ordinary computer system. We describe these advantages in terms of the ecological approach to perception, focusing on three of the consequences of this approach. The first advantage is that human-product interactions can be evaluated. The second concerns the role of perception-action coupling in producing true direct manipulation, allowing designers to interact with their computer on a more intuitive behavioural level than by selecting commands or pushing buttons. The third consequence is the desirability of providing perceptual information about the affordances in the design environment.

The Virtual Workbench: Dextrous VR

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Abstract

Skilled work in a VR environment requires dexterity. Dexterity is more easily achieved by embedding the virtual world in the user's natural work volume than by immersing the user in a beyond-arm's-reach virtual space. We describe a cost-effective means of achieving this, with easily calibrated hand-eye coordination; a stereo display one looks and reaches into. We discuss the hardware and software environments, the calibration required, a test for the support of dexterity, and a preliminary application in the manipulation of medical images.

Keywords: VR, dexterity, hand-eye coordination, calibration, medical.

Panel Session: Enabling Technologies for VR

Chair: Daniel Thalmann
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thalmann@di.epfl.ch
Peter Astheimer,Fraunhofer-Institute for Computer Graphics (IGD) Germany
Luis Serra, National University of Singapore, Singapore
Mel Slater, Queen Mary College, UK

Ideally a virtual reality system and application enables humans to be totally immersed in pseudo-real or imaginary virtual worlds. This is achieved technically by stimulating all human senses (see, hear, touch, taste, smell) and responding to human actions. An application can be qualified as totally immersive when the user is not able to distinguish, whether the world he temporarily inhabitates is virtual or real.
Todays software and hardware technology is far from a realization of such an idealized system. The graphics part of VR-systems - the generation and display of multiple frames per second - is well understood and suitable hardware and software systems generally satisfy our needs. Audio hardware and device controlling software is also available now (multimedia- workstations, Midi-equipment, signal processor based computing units, special devices), although mostly not directly designed and applicable for VR purposes. Force feedback subsystems and tactile displays are slowly being developed and customized. The stimulation of the olfactory and gustatory senses with program controllable subsystems is still subject to experimentation.
With audio hardware and system software readily available it is now possible to take the next evolutionary step and use acoustic simulations

to enhance virtual worlds. Acoustic simulation comprises the generation of the sound itself, the calculation of sound propagation in an environment and the subsequent auralization and spatialization of the computed acoustic parameters. Up to now not all effects experienced in our real world can be simulated in realtime like the computation of sound propagation and subsequent 3d auralization in arbitrary environments. For virtual reality applications powerful workstations or signal processing hardware is needed. An audiovisual system addresses two important human senses at the same time and increases the level of realism towards an ideal immersive system significantly. The incorporation of sound is a first step towards a complete perception system which addresses all human senses.

People communicating in a shared virtual environments may be one of the most important applications of Virtual Reality. Using full teleconferencing is expensive, and only suitable where the meeting participants do not need to share the same virtual space. For example, ISDN rates, even with coding, are relatively slow and it is expensive to produce full colour moving images at 30 frames per second. An alternative may be to transmit only the (changes to) geometry which are elaborated by independent programs at the network nodes. This will enable people to have face-to-face meetings, carry out tasks jointly, and exchange information. It requires not only sufficient bandwidth, but suitable and active representations of the participants in such virtual meetings. Such representations should display not just overall body posture, but also ideally information about facial expression. Enabling technology required for virtual meetings therefore includes both rapid internetworking with suitable protocols for the transfer of geometric data, but also sensors that enable the measurement of behavioural and emotional state. For an interaction between a virtual human and a real one, there is no possibility of transferring data structures, and image understanding methods are required to provide the virtual human with a perception of the real human's behaviour. True interaction between the virtual and the real humans requires a two-way communication between them at the geometric level, at the physical level, and at the behavioral level. At the geometric level, 3D devices like a DataGlove allow the real human to communicate any geometric information to the virtual one. At the physical level, using a force transducer, a force or a torque may be communicated to a virtual human who can apply a force that may be felt by the real human using a force feedback device. It is for example possible to simulate the VR scene where the animator and the virtual human tug on the two ends of a rope. At the behavioral level, we consider emotional communication between the virtual human and the real one, for this kind of emotional exchange mainly based on recognition of facial expressions, only video input seems appropriate.

Finally, for the believability of many VR applications, there is a need for autonomous virtual people, reacting to environments and making decisions based on perception systems, memory and reasoning. A pair of virtual humans interacting is a closed system which can be developed by equipping the virtual humans with complementary behaviours. In order to support interaction and communication, virtual humans should be equipped with the ability to 'recognize' other virtual humans and 'perceive' their facial expressions, gestures and postures. In this case, there is no need for real recognition or perception, of course, because information from the data structures that define these behaviours in one virtual human can be passed directly to a second virtual human.

Invited Talk:

Virtual Reality Teclmologies and its Applications to Industrial Use

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Abstract

Virtual reality, a new paradigm for relationship between humans and computers has been recently well-known and currently investigated for practical use in the various industrial fields. Using three-dimensional computer graphics, interactive devices, and high-resolution display, a virtual world can be realized in which one can pick up imaginary objects as if they were physical world. Using this technology, Matsushita Electric Works, Ltd. has been developing several application systems Jor industrial use since 1990. This paper details three VR application systems operating in the real world: Virtual Space Decision Support System employing Kansei Engineering which is applied for production and sales mainly in the system kitchen business, a telepresence robot system employing semi-autonomous mobile function which is utilized for security field and a low-cost VR system employing physiological feedback mechanism which is used for health care field.

Keywords. Virtual reality, DSS, Kansei engineering, Telepresence, Security system, Mobile Robot, Physiological feedback, Health care.

Paper Session: Novel 3D Techniques & Devices

MULTISENSORY SCIENTlFIC DATA SENSUALIZATION THROUGH VlRTUAL REALITY TECHNOLOGY

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ABSTRACT

Rapid advances in the computational ability of scientific computing systems has given rise to the existence of vast amounts of data.

However, understanding complex phenomena represented by data through conventional data visualization methods alone utilizes only the user's visual sensations. Hence, in this study, virtual reality technology was applied to develop a multisensory data sensualization method using visual, acoustic, and touch sensations to display scientific data. In particular, a prototype wind sensation display system was developed to generate touch sensations for scientific data. Scientific data was represented in various forms of physical stimuli such as color, sound frequency, and wind magnitude. In multisensory data sensualization, accurate and efficient transmission of data from the computer to the user was achieved through the effective integration of several sensations. In this study, we conducted several experiments on the perception of scaler data and vector data in three dimensional space using multisensory data sensualization methods and verified their effectiveness in giving the user accurate perceptions of data. Results indicated that multisensory data sensualization methods can be applied to effectively represent and display scientific data in several engineering fields. In this paper, applications of data sensualization to structural dynamics and fluid dynamics were also illustrated.

AN INERTIAL HEAD-ORIENTATION TRACKER WITH AUTOMATIC DRIFT COMPENSATION FOR USE WITH HMD'S

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ABSTRACT

Current head-tracking technologies suffer from limitations such as delay, limited range, vulnerability to interference, line-of-sight requirements and high cost. In principle, the methods of Inertial Navigation Systems (INS), applied to head-tracking, could overcome these problems. However, inertial head-tracking has been largely neglected due to the difficulty of making a small, light INS that does not drift too much. In order to evaluate the suitability of inertial sensors for use in virtual environment and teleoperator head-tracking applications, an inertial head-orientation tracker has been built and bench-tested for accuracy, resolution, noise, and latency. Yaw, pitch and roll of the head are computed by Euler integration of the outputs of three orthogonal angular rate sensors. Drift compensation is accomplished by making use of natural pauses in head motion to obtain stable readings from a two-axis fluid inclinometer and a fluxgate compass. The system achieves 0.1 ms lag, 0.008° angular resolution, and an unrestricted

working volume. The pitch and roll axes, using a fluid inclinometer for drift compensation, achieve 1° angular accuracy. The drift compensation of the yaw axis using a compass has not yet been evaluated. The results indicate excellent potential for the use of inertial technology in head-tracking, and work is under way to extend the system to 6 degrees of freedom.

A NEW ULTRASONIC POSITIONING PRINCIPLE YIELDING PSEUDO-ABSOLUTE LOCATION

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ABSTRACT

Modulated Phase Coherence (MPC) is a new VR positioning principle. The advantages of MPC include pseudo-absolute position determination and direct measurement of velocity. MPC uses temporal or spatial modulation of a carrier wave to remedy one of the primary drawbacks of Phase Coherent (PC) systems, the lack of absolute position determination. Basic MPC positioning principles are described along with Doppler effect compensation. Three implementation approaches are analyzed. The positive features of the PC approach, high data rates over large volumes, low lag, and good environmental noise immunity, are retained. The intended audience is knowledgable in systems and software, but not necessarily in signal processing or communications. Emphasis is on the interaction of geometry and signal properties.

A STUDY ON THE SYNTHESIS OF ENVIRONMENTAL SOUNDS

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Abstract

HRTF(Head Related Transfer Function)-based acoustic display systems have been studied in parallel with the development of virtual reality technology. However, their initial intended function was only to display the point sound sources to the user in three-dimensional virtual space. Hence, this provided motivation to design and develop a new sound field display system, which could reproduce complex and widespread Environmental Sound Fields (ESF) with a high degree of realism. To develop this system, the understanding of the behaviour of sound waves is crucial. Thus, an ESF display system along with the application of sound and noise principles was developed and tested. The simulation results were used to generate theoretical diagrams of the sound waves generated by point sound sources. Secondly, an experimental prototype speaker system was developed and accurately tested in terms of auditory localization. Furthermore, the ESF display system was implemented into two virtual reality devices. Creation of these graphs and experimental results provided better understanding into the behaviour of the ESF display system and the subjects with respect to integration with conventional virtual reality devices.

Invited Talk:

Virtual Environments in Scientific Visualization

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ABSTRACT

The use of virtual environment (virtual reality) techniques for scientific visualization are surveyed. Lessons learned from vanous existing applications are stated, with regard to implementation areas such as computation, graphics, data management, and user interface. The fruitful interplay of virtual reality and scientific visualization is stressed.

Paper Session: Designing Effective Virtual Worlds

MANAGING MUTUAL AWARENESS IN COLLABORATIVE VIRTUAL ENVIRONMENTS

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ABSTRACT

This paper introduces a spatial model of interaction which aims to support groups of people in using their natural communication skills in distributed virtual environments. First, we outline our motivation for undertaking this work in terms of the social significance of space in supporting co-operative work. Next, we summarise the model's main concepts, namely aura, awareness, focus, nimbus, adapters and boundaries. Following this, we describe routes to implementing the model. The first is an approach suited to realising the model as an application of existing VR platforms. The second is a general implementanon of the model, based on its own specially tailored distributed architecture. Finally, we present our initial observations from use in the laboratory setting and outline issues for future work. 1

REAL TIME GRAPHICS AND VIRTUAL REALITY FOR DRIVING SIMULATION IN URBAN ENVIRONMENTS

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ABSTRACT

The rising interest in the development of medium-size driving simulators with high performance level is leading to the research in Virtual Reality techniques incorporating this technology. The spatial and temporal complexity of the urban environment has not been broached by existing driving simulators, and it offers a good test field to the behavioral simulation algorithms, real time graphics management and VR interaction. This paper presents a method to manage an urban environment complex database, making use of hierarchical elision techniques over a spatial connectivity network. It is also shown how to adapt and refine traffic microsimulation algorithms to provide visual quality in a local area (SMAL algorithm) and it is exposed the connection performed between SMAL and a macroscopic qualitative simulator (QS). Different techniques to achieve a real time 3D rear mirror view capability are explained.

ENVISIONMENTS-CONSTRUCTING DRAMATIC VIRTUAL WORLDS

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ABSTRACT

If virtual worlds are to fulfil their promise as stages for entertainment, education and artistic endeavourr, with who or what shall we people them?? And what methods are available to us to design the dramatic elements of these worlds? Both drama and virtual realities are multi-modal experiences. By drawing on crossover research between the

disciplines of theatre, HCI and system design, we put forward an innovarive basic framework for the design of virtual worlds - an *envisionment*. This paper will examine the nature of interactive experience in relation to user viewpoint and identity, and will develop a frame of reference for the structure and composition of virtual worlds in dramatic terms: location and environment, content, actions, time-scale, events, metaphysical structures and characters. We shall draw attention to the significance of constraints and potentials to envisionment and to techniques drawn from object-oriented analysis and design to model them. We hope that this paper will stimulate a discussion of the issues raised and future directions for research.

Keywords: Virtual Reality, Virtual Worlds, Drama, Human-Computer-Interaction, System Design.

Panel Session: Hands Off My VR: The Role of Gestures in VR

Chair: Mark Green
University of Alberta, Canada
Steve Bryson, NASA Ames, USA
Timothy Poston, National University of Singapore, Singapore
Alan Wexelblat, MIT Media Lab, USA

1. Introduction

What is the role of hands in VR? We use our hands to interact with objects in the real-world, suggesting that hands are the natural input device for VR. But, is this the case? Most input devices require the use of at least one hand, the main issue is how the hand is used to interact with the device. In the case of a glove, the input device attempts to mimic the actions of the user's hand, so the user can use his or her hand in a natural way. For the purpose of this panel session we will call this gesture based input. Other types of input devices, such as buttons mounted on a 3D tracker, can be viewed as tools that the user manipulates with his or her hand. In this case the input device doesn't attempt to mimic a hand. For the purposes of this panel session we will call this tool based input.
Now comes the question, which is best, gesture based or tool based input? There have been no detailed studies done on either style of interaction and we still have very limited experience with the use of these devices, thus this is an excellent topic for a panel session.

Paper Session: Collision Detection

Efficient Virtual Collision Detection for Multiple Users in Large Virtual Spaces

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Science Fiction writes about technology that is still in the Goofy Prototype stage, this is why Virtual Reality is so popular now.

Bruce Sterling, Armadillo Con, 1990, Austin, Texas.

Abstract

Virtual reality researchers are developing technologies to deal with current device limitations. But even with the accompanying advances in raw computer power, VR application designers will always want just a bit more power to make their virtual objects even more convincing. What we need, along with the device advances, is software advances that 'solve' the computationally expensive problems. One is efficiently determining if two objects are touching, which is known as the *collision detection* problem. A prototype system has been built that provides support for collision detection in *real-world* applications. The Virtual Collision detection algorithm scales up to handle tens of thousands of virtual objects and uses order n memory and CPU resources. It supports teams of users in worlds containing objects accessible at various resolutions. The algorithm can also be directly extended to solve other problems such as *view management*.

This paper describes the algorithms from a conceptual and implementation standpoint. Simulation results are then presented.

Virtual and Real Object Collisions in a Merged Environment

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ABSTRACT

See-through head-mounted display capability is becoming an important part of Virtual Environment applications. In such applications, it may be desirable to model the physical behavior of the virtual objects and their interaction with the real objects. This paper describes a software

system which integrates interactive collision detection, collision response and see-through headmounted displays. The system employs a static model of the real world environment and allows for arbitrary convex virtual objects to be placed in the environment. The user may control the positions and velocities of the virtual objects. An approximately constant time collision detection algorithm and a Newtonian Mechanics based single point contact collision response is used to model the apparent physical interaction of the virtual and real objects for moderately complex environments.

Keywords: Virtual Reality, See-through Head-Mounted Displays, Collision Detection, Dynamics, Parallel.

LEVEL-OF-DETAIL GENERATION

AND ITS APPLICATION IN VIRTUAL REALITY

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ABSTRACT

Virtual worlds have to be presented in realtime in order to enable interactive control, viewing and object manipulations. The performance of graphics workstations is limited in the maximum number of polygons which can be processed in realtime. Complex world models (which are of prime interest) exceed this limit easily. A set of rendering techniques allow to handle and conquer complex worlds, where level-of-detail techniques prove to be most promising and successful. This paper introduces an interactive tool with a set of methods for the generation of multiple levels-of-detail of objects, demonstrates several examples and the application within IGD's proprietary VRSystem "Virtual Design".